Stripper Well Consortium
Vortex Flow, LLC Technical Progress Report

Report Title:

"Field Testing of Vortex DXR Retrievable Tool in Conjunction with Other Lifting Methods"

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Abstract

This project was a follow-up project to work completed in 2002 & 2003 where several Vortex downhole tool designs were tested and developed. The work completed in 2003 was designed to determine the effectiveness of technology and related tool design in a field situation and as a means of replacing ESP's and PCP's as artificially lift methods and as a means of increasing production in flowing wells. The work completed in this grant period was designed to determine the effectiveness of the technology in conjunction with other lifting methods.

Twelve gas wells, owned and operated by BP America, were selected for testing. All wells were located in East Texas. Of the twelve installations, ten were successful in adding value to BP. Vortex Tools were able to lower LOE costs and expand the flow time of many wells and help wells to produce more efficient gas/water ratio.

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Executive Summary

In the spring of 2002, Vortex Flow. LLC was awarded a grant by the SWC to research, design and perform lab tests of a downhole tool using the patented Vortex Flow technology. The technology takes a disorganized single or multi-phase flow and transforms it to a spiral flow with an associated boundary layer that runs along the inside wall of the pipe. The vortex flow that is created by the technology reduces friction that causes pressure drops as fluids (gas or liquids) flow through a pipe. The object of applying the technology in a downhole setting is the reduction of pressure drops in a tubing string. Initial tests have shown that the tool has the potential to reduce pressure drops in tubing strings thus increasing production of both gas and oil in low flowrate stripper wells.

Several tool designs were manufactured and later tested at Texas A&M University as part of a Master's Thesis by a graduate student. Initial test results indicated that the final tool design reduced the pressure drop up the tubing string and reduced the required gas flow required to lift liquids up the wellbore. This testing was also the source for an SPE paper (SPE 84136) that was presented at the October '03 Annual SPE Conference in Denver.

In the spring of 2003, Vortex Flow, LLC was awarded a grant to field test the Vortex DX downhole tools with Marathon Oil. The field test results were very encouraging and were the basis for a recent World Oil case study article in the May 2004 issue.

However, as well as the DX tools performed the application of the technology requires the operator to 'pull tubing' to deploy. This requirement greatly increased the cost of a DX project. As a result, Vortex Flow developed a new model of the downhole tool (DXR) that is able to be deployed via slickline through the tubing string and set downhole in a collar stop. Vortex Flow has been installing these tools with customers since January of 2004. The DXR tools dramatically reduce the cost to deploy the Vortex tools and can enable the installation to be economically viable for many more lower-rate wells.

Based on field data to date, it appears that the DXR tools can indeed enable a well to 'flow' even with only 75% of the required critical gas rate. However, many stripper gas wells are further below that critical gas rate level. Vortex believes that the DXR tools could still provide significant economic benefit to such lower rate wells when deployed in tandem with other low cost liquid lifting methods such as surfactants, plunger lifts and velocity strings.

In 2004, Vortex submitted a proposal to determine the extent that a DXR tool can enhance a well's performance in conjunction with certain other liquid lifting techniques. **It is believed that by combining a DXR tool with other lower cost lifting methods that the combined solution will further lower the critical gas rate required to keep a well flowing to as low as 40% of the critical gas rate and could replace a larger number of more expensive traditional lifting methods such as mechanical pumping units.**

Objectives

There were three key objectives to the project:

1) Install and test 15 downhole DXR tools in actual operating wells to measure efficacy of the tool in a wide range of operating conditions.
    - 8 wells with plunger lift
    - 5 wells with soap
    - 2 wells with velocity strings – coiled tubing
2) Collect and analyze data from the operating tests as a basis for conclusion on impact on production.
3) Determine effective operational envelope of the DXR tools with the other lifting technologies.

Methods to Be Employed

- Install DXR tools for field test
- Field test DXR tools and collect associated data.
- Data analysis as a means of generating transfer and operating functions for the tool.

It was fully expect that the results indicated by the initial lab tests at Texas A&M on the original DX design and the field tests conducted by Marathon will be supported by data as the Vortex DXR tool is tested.

Results & Discussion:

The Vortex Downhole tool can work effectively in conjunction with other producing methods. From the limited information that could be gathered, we feel that in certain situations and well conditions, the Vortex tool can help. From the brief data gathered, Vortex now has a better understanding of what situations and well conditions we can help other producing methods be more effective. Results attachment lists the types of installations and results. 15 tools were to be installed for the study, however, since the study BP chose not to continue with the study, the remaining three were never installed.

Well Name	Install Date	Tubing Size	Tool	Typical Pre-Prod	Typical Pre-H2O	Post Prod	Post H2O	Test	Vortex Value Proposition	Results
Price 8	*****	2 3/8	DXR	400 mcfd	50 bbld	400 mcfd	+50 bbld	Automated Foamer	Reduce the amount of surfactant being used.	Surfactant usage reduced by 50%
Price 11	*****	2 3/8	DXR	450 mcfd	130 bbld	450 mcfd	+120-140 bbld	Automated Foamer	Reduce the amount of surfactant being used.	Surfactant usage reduced by 50%
Price 12		2 3/8	DX					Automated Foamer	Reduce the amount of surfactant being used.	Well able to flow 24/7 at an estimated 50% of the critical gas rate with combination of soap and Vortex DX tool. Once gas flow rate drops below the rate to continually lift water 24/7, an intermitter may be a good solution. Probably should at least be tried prior to going to a more expensive solution such as a pump jack.
GCU 12-2	9/15/03	2 3/8	DX					Vortex		Casing pressure would never get below 60 PSI with a plunger. With Vortex DX casing was consistently running at 40 PSI. Well was able to produce with far less casing pressure for a period of 9 mo. Casing pressure would not have supported being produced via a plunger.
Burnett Bros. 22	6/5/04	2 3/8	DXR	175 mcfd	10 bbld	190 mcfd		Vortex	Reduced operating costs from the pacemaker/plunger.	Gas rate increased about 15 mcfd (13%). Well flowing consistently and casing/tubing pressure has been narrowed with the DXR tool in place from 50-55 PSI to 40-45PSI. DXR is producing a more efficient gas/water flow regime and has reduced the multi-phase friction as the flow moves up the tubing.
GCU 9-7	6/5/04	2 3/8	DXR	240 mcfd	40 bbld	240 mcfd	40 bwd	Pad Plunger	See if DXR can replace a plunger lift. (Well is slightly beyond the droplet model for gas lifting liquid. 30 minutes typically required to lift water from the wellbore during plunger cycle.)	DXR is matching the production rates obtained by the plunger. Well is unable to flow 24/7 for an extended period of time post installation although the curve was flattened - indicating a better flow capability with DXR in place. Suggest this well as a candidate to stack a second tool in the middle of tubing.
Hicks 7	*****	2 3/8	DXR	100 mcfd		140 mcfd		Pad Plunger Lift	To increase the effectiveness of the pad plunger. Enable the after flow cycle to produce more water and extend the	Increase in plunger effectiveness.
GCU 13-13	5/6/04	2 3/8	DXR	275 mcfd				Phase 1 Liquid Loadin	Want to maintain well as flowing well longer before experiencing slugging or well loading. Estimated to have a flow rate just above critical.	Well flowing consistently with slight downtrend in casing pressure.
Galarpie		2 3/8	DXR	160-200 mcfd w/ pace maker	<10 bbld			Vortex/Intermitter	Pre-Vortex- would not run consistently with plunger.	Kicked off strong, but would not flow 24/7 with DXR in place. Pacemaker was put back in, but as of 7/19/04 not producing any gas.
Wilcher		2 3/8	DXR					Vortex/Intermitter	To effectively deliquify well with Vortex DXR and intermitter instead of with a pacemaker plunger.	Kicked off strong, but would not flow 24/7 with DXR in place. Must have timer on for any hope of consistent deliquification. Changed the cycle setting to wait until pressure in well builds to 70 PSI prior to cycling (instead of 50 PSI) Time required to build pressure in the tubing is very contingent on level of liquid loading in tubing. Seems to flow about 12 hrs/day at a rate of 120 mcfd.
Braun 7	*****	2 3/8	DXR	Shut-In				Vortex/Intermitter	To effectively deliquify well with Vortex DXR and intermitter instead of with a pacemaker plunger.	Well able to produce an average of 50 mcfd with DXR & automated intermitter in place.

Conclusion:

- The Vortex tools can work effectively with automated foamers and enable a significant reduction (up to 50%) in surfactant used on wells with automated foamers.
  - Price 8, Price 11, Jones 1, Price 12
- The Vortex tools can further lower the FBHP compared to pad plunger lift or Pacemaker plunger tools.
  - CGU 12-2, Burnett Bros 22 CV
- Vortex tools can replace a pad plunger and enable well to be produced effectively.
  - GCU 9-7
- The Vortex tools can improve production with a pad plunger from a pad plunger alone – lift more water during each after flow period and extend the flowing portion of the plunger "on" cycle.
  - Hicks 7
- Reduce current Phase 1 liquid loading (well flowing at or above critical gas rate but with higher casing pressure than optimum)…increase gas production and extend the flowing life of the well.
  - GCU 13-13
- In lower producing wells that have a history of rapid gas rate declines, an intermitter/Vortex combination is definitely required (automated intermitter is preferred to maximize on-time).

    - Galespie, Wilcher, Brown 7
- Effectively deliquify well with a Vortex and Intermitter Combo – improve any well currently being intermitted with a Vortex tool.
    - This production solution has a very broad application and significant impact as a low LOE but effective production option for BP.
    - 2 installations were not successful. It is still uncertain why these particular applications did not work. Since the study was terminated we were not able to gather enough information.

References:

None